

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
United States Patent and Trademark
Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 12 October 2000 (12.10.00)	
International application No. PCT/EP00/01950	Applicant's or agent's file reference HO979PCT/Zu/K
International filing date (day/month/year) 02 March 2000 (02.03.00)	Priority date (day/month/year) 03 March 1999 (03.03.99)
Applicant VAN DER AA, Michiel, Adrianus, Henricus et al	

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

14 August 2000 (14.08.00)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Olivia TEFY

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

Kruit, Jan
CORUS TECHNOLOGY BV
P.O. Box 10000
NL-1970 CA IJmuiden
PAYS-BAS

3.3.99

entry → 3.9.2001

05 JAN 2001

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing
(day/month/year)

03.01.2001

Applicant's or agent's file reference
HO979PCT/HdG/H

IMPORTANT NOTIFICATION

International application No.
PCT/EP00/01950

International filing date (day/month/year)
02/03/2000

Priority date (day/month/year)
03/03/1999

Applicant
CORUS STAAL BV

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer

Dolezel, A

Tel. +49 89 2399-2940



PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference HO979PCT/HdG/H	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/EP00/01950	International filing date (<i>day/month/year</i>) 02/03/2000	Priority date (<i>day/month/year</i>) 03/03/1999
International Patent Classification (IPC) or national classification and IPC B21D22/30		
Applicant CORUS STAAL BV		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 7 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☒ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 14/08/2000	Date of completion of this report 03.01.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Vinci, V Telephone No. +49 89 2399 2364



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/01950

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:

Description, pages:

1-5 as originally filed

Claims, No.:

1-26 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/01950

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

- ☐ restricted the claims.
- ☐ paid additional fees.
- ☐ paid additional fees under protest.
- ☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

- ☐ complied with.
- ☒ not complied with for the following reasons:
see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

- ☒ all parts.
- ☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-26
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-26
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-26
	No:	Claims	

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/EP00/01950

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item IV

Lack of unity of invention

The separate inventions are:

Claims 1 to 12 and 17 to 26

Process and tool for the wall ironing of a product in sheet form, whereby the forming surface of the tool forms an entry angle with respect to the direction of movement of the product, which varies over the length of the forming surface, in the direction of movement of the product past the forming surface, this entry angle being smaller in a starting zone of the forming surface than in the subsequent zone thereof.

Claims 13 to 16

Process and tool for the wall ironing of a product in sheet form, whereby the forming surface of the tool forms an entry angle with respect to the direction of movement of the product, said product being formed from a metal sheet coated on at least one side with a plastic layer, whereby specific boundary conditions for some parameters defining the plastic layer to be used, namely μ_0 =pressure sensitivity of the plastic, T_0 =base level for the yield stress and a time constant A_0 , must be satisfied.

There is therefore no special technical feature or common technical concept linking together the inventions above so as to form a single general inventive concept (Rule 13.1 PCT).

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

The present invention refers to a process and a tool for wall ironing of a product in sheet form, which is formed from a metal sheet coated on at least one side with a plastic layer, whereby the forming surface of the tool forms an entry angle with respect to the direction of movement of the product, according to the preambles of claims 1 and 13 (process) and 17 (tool) respectively. The closest prior art is represented by the EP-A-0 298 560 cited on

page 1 of the description.

The technical problem to be solved has to be seen in reducing the spreading forces which increase when a very small entry angle is used while avoiding at the same time breakage of the plastic layer which could be stripped from the metal sheet occurring when a larger angle is used.

The subject-matter of claims 1, 13 and 17 differs from this prior art in the features defined in the characterizing portions of these claims, so as they meet the requirements of Art. 33(2) PCT with respect to novelty.

An inventive technical contribution has to be seen in the use of an entry angle varying over the length of the forming surface as stated in the characterising portion of these claims. In the starting zone with the small entry angle a high pressure on all sides builds up in the material, and this pressure is maintained during the subsequent forming in the subsequent zone with a larger angle. This high pressure, as found out by the Applicant, increases the fracture limit of the plastic material thus reducing the risk of breaking the plastic layer and allowing larger entry angle to be used in particular in the intermediate zone (see also description, page 2, line 3 onwards).

The particular boundary conditions set in method claim 13, which is drafted as independent claim, reduce the risk of the plastic layer fracturing in the zone with larger entry angle and this taking the characteristics of the particular material used into account.

The subject-matter of claims 1, 13 and 17 thus also meet the requirements of Art. 33 (3) PCT having regard to inventive step.

Claims 2 to 12, 14 to 16 and 18 to 26 are dependent on claims 1, 13 and 17 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.

The subject-matter of claims 1 to 26 is unambiguously susceptible of industrial application.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/EP00/01950

Re Item VIII

Certain observations on the international application

The expression "under an elevated pressure P_0 " used in claim 13 is vague and unclear and leaves the reader in doubt as to the meaning of the value of the pressure to be applied, thereby rendering the definition of the subject-matter of said claim and of the protection afforded unclear (Article 6 PCT).

Moreover, claims 13, line 21, refers to the description. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

PATENT COOPERATION TREATY

PCT

REC'D 05 JAN 2001

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference HO979PCT/HdG/H	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/EP00/01950	International filing date (day/month/year) 02/03/2000	Priority date (day/month/year) 03/03/1999
International Patent Classification (IPC) or national classification and IPC B21D22/30		
Applicant CORUS STAAL BV		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


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- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☒ Lack of unity of invention
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Date of submission of the demand 14/08/2000	Date of completion of this report 03.01.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Vinci, V Telephone No. +49 89 2399 2364



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/01950

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).):*

Description, pages:

1-5 as originally filed

Claims, No.:

1-26 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

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- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
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3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

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- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
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- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/01950

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

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- ☐ paid additional fees.
- ☐ paid additional fees under protest.
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- ☐ complied with.
- ☒ not complied with for the following reasons:
see separate sheet

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- ☒ all parts.
- ☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-26
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-26
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-26
	No:	Claims	

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/EP00/01950

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re Item IV

Lack of unity of invention

The separate inventions are:

Claims 1 to 12 and 17 to 26

Process and tool for the wall ironing of a product in sheet form, whereby the forming surface of the tool forms an entry angle with respect the direction of movement of the product, which varies over the length of the forming surface, in the direction of movement of the product past the forming surface, this entry angle being smaller in a starting zone of the forming surface than in the subsequent zone thereof.

Claims 13 to 16

Process and tool for the wall ironing of a product in sheet form, whereby the forming surface of the tool forms an entry angle with respect to the direction of movement of the product, said product being formed from a metal sheet coated on at least one side with a plastic layer, whereby specific boundary conditions for some parameters defining the plastic layer to be used, namely μ_0 =pressure sensitivity of the plastic, τ_0 =base level for the yield stress and a time constant A_0 , must be satisfied.

There is therefore no special technical feature or common technical concept linking together the inventions above so as to form a single general inventive concept (Rule 13.1 PCT).

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

The present invention refers to a process and a tool for wall ironing of a product in sheet form, which is formed from a metal sheet coated on at least one side with a plastic layer, whereby the forming surface of the tool forms an entry angle with respect the direction of movement of the product, according to the preambles of claims 1 and 13 (process) and 17 (tool) respectively. The closest prior art is represented by the EP-A-0 298 560 cited on

page 1 of the description.

The technical problem to be solved has to be seen in reducing the spreading forces which increase when a very small entry angle is used while avoiding at the same time breakage of the plastic layer which could be stripped from the metal sheet occurring when a larger angle is used.

The subject-matter of claims 1, 13 and 17 differs from this prior art in the features defined in the characterizing portions of these claims, so as they meet the requirements of Art. 33(2) PCT with respect to novelty.

An inventive technical contribution has to be seen in the use of an entry angle varying over the length of the forming surface as stated in the characterising portion of these claims. In the starting zone with the small entry angle a high pressure on all sides builds up in the material, and this pressure is maintained during the subsequent forming in the subsequent zone with a larger angle. This high pressure, as found out by the Applicant, increases the fracture limit of the plastic material thus reducing the risk of breaking the plastic layer and allowing larger entry angle to be used in particular in the intermediate zone (see also description, page 2, line 3 onwards).

The particular boundary conditions set in method claim 13, which is drafted as independent claim, reduce the risk of the plastic layer fracturing in the zone with larger entry angle and this taking the characteristics of the particular material used into account.

The subject-matter of claims 1, 13 and 17 thus also meet the requirements of Art. 33 (3) PCT having regard to inventive step.

Claims 2 to 12, 14 to 16 and 18 to 26 are dependent on claims 1, 13 and 17 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.

The subject-matter of claims 1 to 26 is unambiguously susceptible of industrial application.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/EP00/01950

Re Item VIII

Certain observations on the international application

The expression "under an elevated pressure P_0 " used in claim 13 is vague and unclear and leaves the reader in doubt as to the meaning of the value of the pressure to be applied, thereby rendering the definition of the subject-matter of said claim and of the protection afforded unclear (Article 6 PCT).

Moreover, claims 13, line 21, refers to the description. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference H0979PCT/Zu/K	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/EP 00/ 01950	International filing date (day/month/year) 02/03/2000	(Earliest) Priority Date (day/month/year) 03/03/1999
Applicant HOOGO VENS STAAL BV et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1
☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/01950

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B21D22/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	✓ EP 0 298 560 A (HOOGOVS GROEP BV) 11 January 1989 (1989-01-11) cited in the application the whole document	1, 13, 17
A	✓ US 4 254 652 A (PROCTOR HARRY P) 10 March 1981 (1981-03-10)	
A	✓ US 4 018 075 A (KAWAWA HIROYUKI ET AL) 19 April 1977 (1977-04-19)	

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

6 June 2000

Date of mailing of the international search report

15/06/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Peeters, L

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/01950

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0298560	A	11-01-1989	NL 8701623 A	01-02-1989
			CA 1306973 A	01-09-1992
			DE 3874632 A	22-10-1992
			DE 3874632 T	04-03-1993
			DK 381788 A	11-01-1989
			GR 3005714 T	07-06-1993
			IL 86975 A	10-03-1991
			JP 1027725 A	30-01-1989
			US 4881394 A	21-11-1989
US 4254652	A	10-03-1981	DE 2967280 D	06-12-1984
			EP 0007178 A	23-01-1980
US 4018075	A	19-04-1977	JP 963472 C	20-07-1979
			JP 51130670 A	13-11-1976
			JP 53044419 B	29-11-1978
			BG 27350 A	12-10-1979



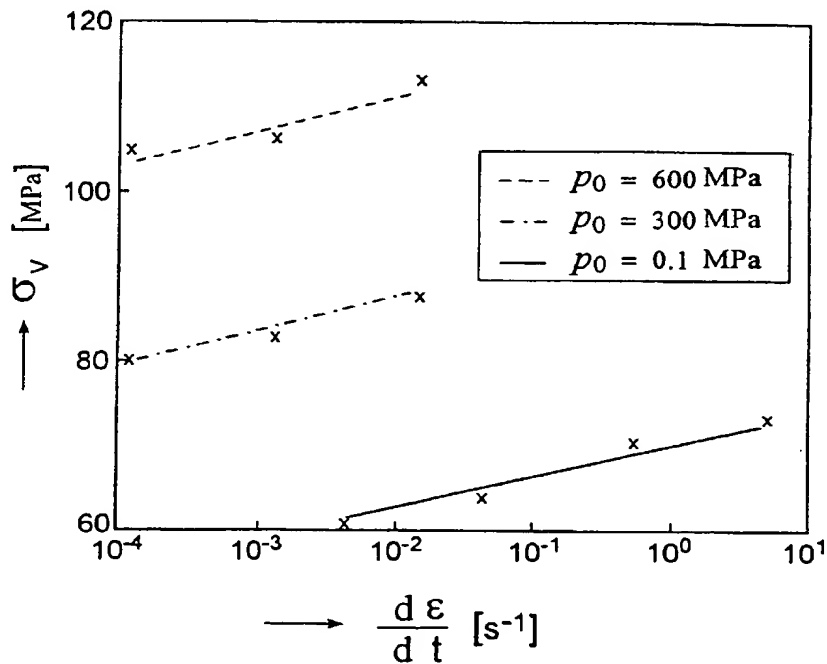
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: PROCESS FOR THE WALL IRONING OF A PRODUCT IN SHEET FORM, AND A WALL IRONING TOOL

(57) Abstract

Process for the wall ironing of a product in sheet form, which is formed from a metal sheet coated on at least one side with a layer of plastic, the wall-ironing tool comprising a forming surface which the product with a plastic coating layer moves along during the wall ironing, and the forming surface being at an entry angle with respect to the direction of movement of the product, whereby the entry angle varies over the length of the forming surface, in the direction of movement of the product past the forming surface, this entry being smaller in a starting zone of the forming surface than in the subsequent zone thereof.



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PROCESS FOR THE WALL IRONING OF A PRODUCT IN SHEET FORM, AND A WALL IRONING TOOL

The invention relates to a process for the wall ironing of a product in sheet form, which is formed from a metal sheet coated on at least one side with a layer of plastic, the wall-ironing tool comprising a forming surface which the product with a plastic coating layer moves along during the wall ironing, and the forming surface being at an entry angle with respect to the direction of movement of the product. A process of this nature is in widespread use for the production of a can comprising a base and a tubular body, although the invention is not limited to this particular application.

The entry angle forms an important parameter in wall ironing. It has been found that with a very small entry angle the spreading force, that is to say the force which acts on the forming surface transversely with respect to the direction of movement of the product, becomes very high. For example, in the case of wall ironing of cans, this may lead to extreme loads being imposed on the wall-ironing ring used, which may consequently be damaged or even break.

Selecting a larger entry angle runs the risk of the plastic layer breaking and being stripped off the metal sheet. This is because a larger entry angle results in a greater longitudinal force being exerted on the plastic layer in the direction of movement, with the result that the stress in the said plastic layer exceeds a fracture limit.

Proposals have previously been made for making the process more suitable for working with plastic-coated metal sheet. In European Patent EP 0,298,560, it is proposed that additional lubrication be used during the wall ironing, and specific entry angles are proposed for successive wall-ironing rings. Nevertheless, there is a continuing need to work with larger entry angles, in order to be able to achieve longer service lives of the wall-ironing tool. The present invention now offers a solution enabling the risk of the plastic layer breaking and being stripped off during wall ironing to be reduced, so that larger entry angles can be used.

The invention is based on making use of the observed fact that many plastics materials exhibit a higher fracture limit during forming as the pressure on all sides increases. The appended figure shows results of the correlation between the forming rate ($d\varepsilon/dt$ in s^{-1}), plotted on the horizontal axis, and the yield stress σ_y in MPa, plotted on the vertical axis, and the prevailing pressure P_0 in MPa on all sides. This figure works on the basis of a polyethyleneterephthalate (PET), with lines illustrating results of model studies and crosses indicating the results of experiments. It can be clearly seen from this figure that the yield stress is considerably higher as the pressure on all sides rises. The object of the invention is therefore to produce a high pressure on all sides at the location where the coated metal sheet is being wall-ironed using a large entry angle,

without it being necessary to apply a very high pressure to the entire wall-ironing installation.

The invention therefore consists in the fact that the entry angle varies over the length of the forming surface, in the direction of movement of the product past the forming surface, this entry angle being smaller in a starting zone of the forming surface than in the subsequent zone thereof. The result of this measure is that, in the starting zone with the small entry angle, a high pressure on all sides is built up in the material, and this pressure is maintained during the subsequent forming in the subsequent zone with a larger entry angle. In the zone where the actual forming takes place, a high pressure prevails on all sides, yet nevertheless a relatively low spreading force is exerted on the forming surface (for example a wall-ironing ring).

The high pressure which is generated on all sides in the plastic layer may relax slightly towards the chamber after the wall-ironing tool has been passed, towards the end of the zone with the larger entry angle. This may mean that the fracture stress of the plastic material is reduced again at that location, causing it to fracture and be stripped off by the wall-ironing tool. For this reason, it has proven advantageous for the forming surface in an end zone to again be at a smaller entry angle than in the intermediate zone.

An improvement is also achieved if the forming surface, following the zone with the largest entry angle, comprises a so-called land zone, with an entry angle of 0°. The length of this land zone may be between 0.3 and 1.5 mm.

In one possible application of the invention, the entry angle may have a fixed value in each of the said zones. However, under certain circumstances it may be preferable for the entry angle to change smoothly over the length of the forming surface. This prevents sudden changes in stress in the material to be wall ironed, so that, under certain circumstances, the wall ironing can proceed more successively.

In the preferred embodiment of this smooth change, the transitions between the successive zones, and/or the zones themselves, run in the form of an arc of a circle. Good results are obtained if the radius of this arc is between 0.1 and 10 mm long.

Particularly if the novel process is used for the wall ironing of a product which ultimately acquires the shape of a can, it is advantageous for the wall-ironing tool to comprise a plurality of wall-ironing rings of the type described above. In particular, it has proven advantageous for between 60 and 90% of the total wall thinning to be produced by the corresponding forming surface in the zone which runs at the largest entry angle, the so-called main zone. A further improvement is obtained if between 10 and 30% of the total wall thinning is produced by the corresponding forming surface in the starting zone. Furthermore, it is advantageous, if an end zone is also being used, for less than 30% of the total wall thinning to be produced by the corresponding forming surface in this end zone.

As explained above, it is possible, when using the novel process according to the invention, to use a larger entry angle in particular in the intermediate main zone, allowing the mechanical load on the forming surface, i.e. the wall-ironing ring, to be reduced. Despite this larger entry angle, it is generally possible, by using a starting zone and an end zone with a smaller entry angle, to prevent the plastic coating layer from yielding and being stripped off.

When using various plastics in various layer thicknesses and on various types and thicknesses of metal sheet, the limiting conditions for the entry angle in the intermediate zone and the entry angle and the length of the starting zone and the end zone will generally be different if it is desired to work using conditions which are optimal for all ironing without there being any risk of the plastic layer fracturing and being stripped off. It has been found that for various materials applications, the optimum conditions can be determined by means of experiments using forming surfaces (for example of wall-ironing rings) in which the length of the starting zone and/or the end zone is varied.

During the wall ironing of a plastic-coated metal sheet, the following functional relationship applies to the yield stress σ_v (in MPa) in the plastic:

$$\sigma_v = \frac{3}{\sqrt{3} + \mu} \cdot [\tau_0 \ln(2\sqrt{3} \cdot A_0 \cdot d\varepsilon/dt) + \mu P_0], \text{ where:}$$

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P_0 is the pressure in MPa prevailing on all sides in the plastic;

τ_0 is a base level for the yield stress in MPa;

$d\varepsilon/dt$ is the drawing speed of the plastic being formed in sec^{-1} ;

μ is a unit-free parameter which represents the pressure sensitivity of the plastic;

A_0 represents a time constant (in sec) which is related to the relaxation behaviour of the plastic.

According to the invention, it has been found that the wall ironing of a coated product in sheet form at an elevated pressure on all sides P_0 only takes place successively if the values of the parameters μ , τ_0 and A_0 of the plastic used for the coating satisfy specific boundary conditions. These values must be as follows:

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$$\mu \geq 0.03; \tau_0 \geq 0.60 \text{ MPa and } A_0 \geq 2.0 \times 10^{19} \text{ sec.}$$

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It is preferable to use plastics in which the parameters are as follows:

$$\mu \geq 0.047; \tau_0 \geq 0.90 \text{ MPa and } A_0 \geq 3.0 \times 10^{19} \text{ sec.}$$

It has been found that what is known as the glass transition temperature T_g of the plastic is important in the wall ironing of a plastic-coated metal sheet. T_g is the transition point for the properties of the amorphous range in the plastic. In principle, below T_g free movement of the main chain of the polymer is impossible. Above T_g , this freedom of movement is possible, leading to the hardness of the material falling by orders of magnitude. Since many plastics are partially crystalline, and this part partially retains its strength up to the melting point, many plastics materials can still be used very well up to temperatures far above T_g .

In the case of wall ironing, the level of T_g is important because the plastic must still have a relatively high mechanical strength during the wall ironing. A plastic coating with a low T_g may possibly acquire sufficient strength by building up a very high pressure in the wall-ironing tool. However, just outside this pressure zone the plastic is so "weak" that it is immediately pressed away and scrapped off.

During the wall-ironing process, a considerable rise in temperature takes place in the ironed material. This temperature may rise to approx. 200°C.

It has been found that a plastic-coated metal sheet can be successfully wall-ironed if the T_g of the plastic is sufficiently high under various conditions. The T_g at atmospheric pressure, $T_{g, 1 \text{ atm}}$, and the T_g when the plastic is under a pressure on all sides of 600 MPa, $T_{g, 600 \text{ MPa}}$, have proven particularly important in this context. According to the invention, $T_{g, 1 \text{ atm}}$ and $T_{g, 600 \text{ MPa}}$ must be as follows: $T_{g, 1 \text{ atm}} \geq 30^\circ\text{C}$ and $T_{g, 600 \text{ MPa}} \geq 200^\circ\text{C}$. Preferably, $T_{g, 1 \text{ atm}}$ must be as follows: $T_{g, 1 \text{ atm}} \geq 70^\circ\text{C}$.

In addition to the process described above, the invention also relates to a wall-ironing tool, in particular a wall-ironing ring, comprising a forming surface, past which a sheet-like product can be moved during the wall ironing, which forming surface is at an entry angle with respect to the direction of movement of the product. This wall-ironing tool is characterized in that the entry angle varies over the length of the forming surface, in the direction of movement of the product, this angle being smaller in a starting zone of the forming surface than in the subsequent zone thereof.

Numerous preferred embodiments of the wall-ironing tool according to the invention have been explained in the preceding description of the novel process, to which reference is made here.

A particular preferred embodiment of a wall-ironing ring according to the invention is also that this wall-ironing ring is under a radial prestress on its outer circumferential surface, due to a strip or wire which has been wound around it under stress.

Wall-ironing rings are generally known, as are the associated terms such as entry angle, main zone and land zone.

Therefore, there is no need for the wall-ironing rings discussed to be explained in more detail in a description referring to figures.

CLAIMS

1. Process for the wall ironing of a product in sheet form, which is formed from a metal sheet coated on at least one side with a layer of plastic, the wall-ironing tool comprising a forming surface which the product with a plastic coating layer moves along during the wall ironing, and the forming surface being at an entry angle with respect to the direction of movement of the product, characterized in that the entry angle varies over the length of the forming surface, in the direction of movement of the product past the forming surface, this entry being smaller in a starting zone of the forming surface than in the subsequent zone thereof.
2. Process according to Claim 1, characterized in that the forming surface in an end zone is again at a smaller entry angle than in the intermediate zone.
3. Process according to Claim 1 or 2, characterized in that the forming surface, following the zone with the largest entry angle, comprises a so-called land zone, with an entry angle = 0° .
4. Process according to Claim 2 or 3, characterized in that the entry angle has a fixed value in each of the zones.
5. Process according to Claim 2 or 3, characterized in that there is a smooth change in the entry angle over the length of the forming surface.
6. Process according to Claim 5, characterized in that the transitions between successive zones, and/or such zones themselves run in the form of an arc of a circle.
7. Process according to one of the preceding claims, characterized in that the wall-ironing tool comprises a plurality of forming surfaces.
8. Process according to one of the preceding claims, characterized in that the wall-ironing tool comprises a plurality of wall-ironing rings.
9. Process according to one of the preceding claims, characterized in that 60 to 90% of the total wall thinning is produced by the corresponding forming surface in the zone running at the largest entry angle, the so-called main zone.

10. Process according to Claim 9, characterized in that 10 to 30% of the total wall thinning is produced by the corresponding forming surface in the starting zone.
- 5 11. Process according to Claim 9 or 10, characterized in that less than 30% of the total wall thinning is produced by the corresponding forming surface in the end zone.
- 10 12. Process according to one of the preceding claims, characterized in that the length of the starting zone and/or of the end zone, under otherwise identical conditions, is set in such a way that the plastic coating is not torn off the metal sheet as a result of the wall ironing.
- 15 13. Process for the wall ironing of a product in sheet form, which is formed from a metal sheet coated on at least one side with a layer of plastic, the wall-ironing tool comprising a forming surface which the product with a plastic coating layer moves along during the wall ironing, and the forming surface being at an entry angle with respect to the direction of movement of the product, characterized in that, in a zone of the forming surface which runs at the largest entry angle, the plastic layer is held under an elevated pressure P_0 (in MPa) on all sides, and that
20 the plastic used for the coating layer is characterized by values of the parameters μ (no units); τ_0 (in MPa) and A_0 (in sec), as defined in the description, which are as follows:

25 $\mu \geq 0.03$; $\tau_0 \geq 0.60$ and $A_0 \geq 2.0 \times 10^{19}$.
14. Process according to Claim 13, characterized in that the parameters μ , τ_0 and A_0 are as follows: $\mu \geq 0.047$; $\tau_0 \geq 0.90$ and $A_0 \geq 3.0 \times 10^{19}$.
- 30 15. Process according to Claim 13 or 14, characterized in that the plastic used is also characterized by values for the parameters $T_{g, 1 \text{ atm}}$ and $T_{g, 600 \text{ MPa}}$ (in °C), as defined in the description, which are as follows: $T_{g, 1 \text{ atm}} \geq 30^\circ\text{C}$ and $T_{g, 600 \text{ MPa}} \geq 200^\circ\text{C}$.
- 35 16. Process according to Claim 15, characterized in that the parameter $T_{g, 1 \text{ atm}}$ is as follows: $T_{g, 1 \text{ atm}} \geq 70^\circ\text{C}$.
17. Wall-ironing tool, in particular a wall-ironing ring, comprising a forming surface, along which a sheet-like product can be moved during the wall ironing, which forming surface is at an entry angle with respect to the direction of movement of

the product, characterized in that the entry angle varies over the length of the forming surface, in the direction of movement of the product, this angle being smaller in a starting zone of the forming surface than in the subsequent zone thereof.

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18. Wall-ironing tool according to Claim 17, characterized in that the forming surface in an end zone is again at a smaller entry angle than in the intermediate zone.
19. Wall-ironing tool according to Claim 17 or 18, characterized in that between the
10 intermediate zone and the end zone there is a land zone with a length of between 0.3 and 1.5 mm.
20. Wall-ironing tool according to one of Claims 17-19, characterized in that the entry angle has a fixed value in each of the zones.
- 15 21. Wall-ironing tool according to one of Claims 17-19, characterized in that there is a smooth change in the entry angle over the length of the forming surface.
22. Wall-ironing tool according to Claim 21, characterized in that the transitions
20 between successive zone, and/or the zones themselves, run in the form of an arc of a circle with a radius of a length of between 0.1 and 10 mm.
23. Wall-ironing tool according to one of Claims 17-22, characterized in that the
25 main zone forms between 60 and 90% of the transverse dimension of the forming surface, transversely with respect to its longitudinal direction.
24. Wall-ironing tool according to Claim 23, characterized in that the starting zone forms between 10 and 30% of the transverse dimension of the forming surface.
- 30 25. Wall-ironing tool according to Claim 23 or 24, characterized in that the end zone forms less than 30% of the transverse dimension of the forming surface.
26. Wall-ironing tool in the form of a wall-ironing ring, according to one of Claims
35 17-25, characterized in that this wall-ironing ring is under a radial prestress on its outer circumferential surface, due to a strip or wire which has been wound around it under stress.

